

BCM4100/BCM4210

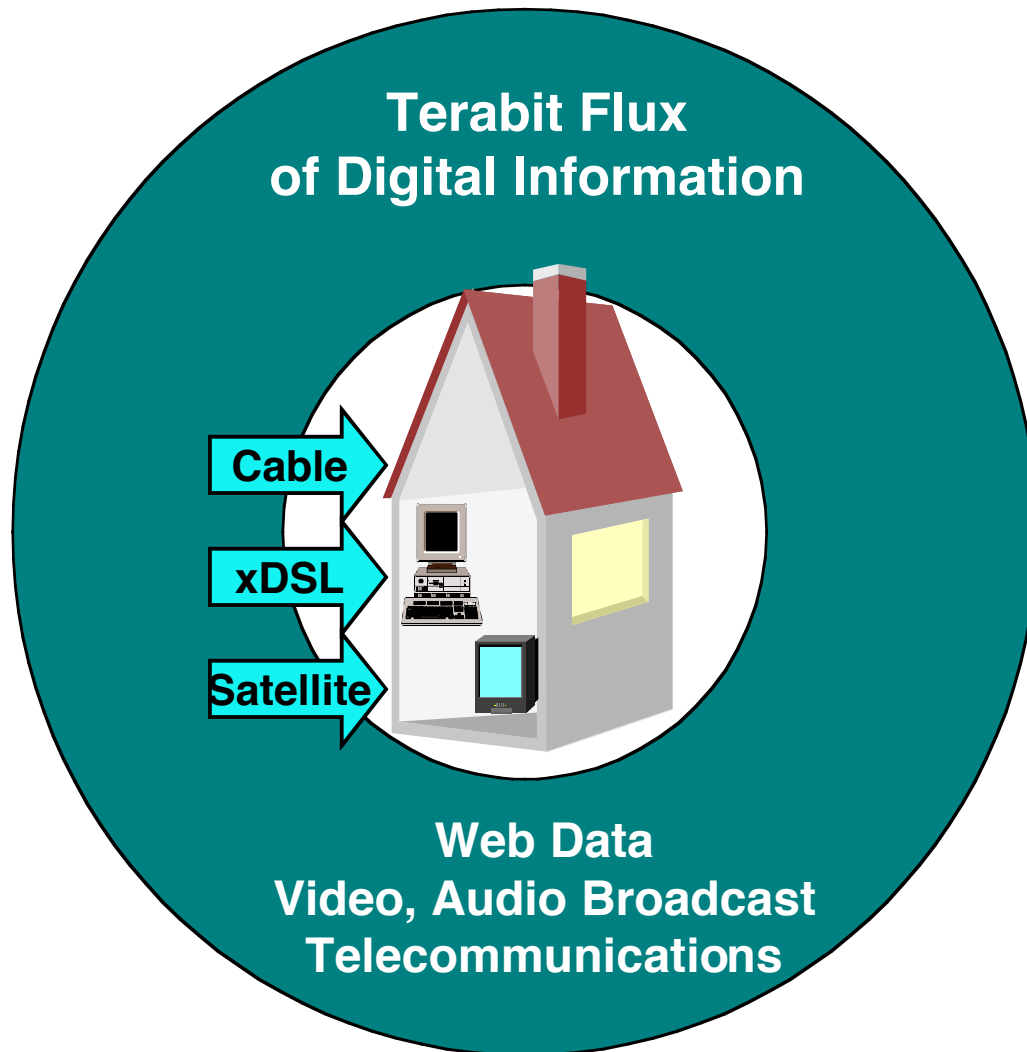
A Chipset for 16 Mbps Phonetline Networking

Broadcom Home Networking Division

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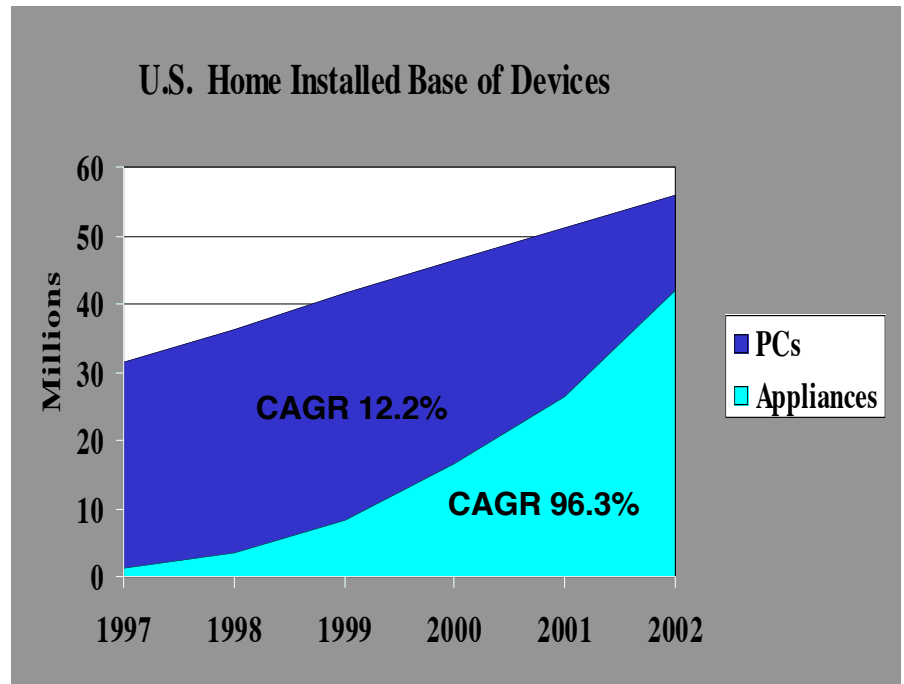
The Home Castle with Information Moat



- Lots of content from the outside
- Lots of single purpose devices on the inside
- A move from analog to digital
- Wide-area draw-bridges across the moat
- But no good way to connect everything on the inside

Everything will be Networked

- **Shared internet access**
 - PC's
- **Shared video appliances**
 - VCRs, DVDs
 - TV on PC, PC on TV
- **Internet appliances**
 - Radios
 - WebTV
 - Handheld computers, etc.
- **Telephones**
 - IP phones
 - Video phones
- **Streaming Internet Audio and Video**



International Data Corp. Research



Home Network Media Choices

- **New wires versus no new wires**
 - Consensus is that new wiring is a non-starter for volume deployment
 - 10/100 Base-T, P1394 are not realistic choices
- **Three principal choices for no new wires**
 - Phone line High performance, secure, simple to use, the plug used today, low cost, an industry standards organization that works (HPNA), but arbitrary wiring and devices
 - Power line Ubiquitous, but not robust, lower data rates, privacy issues, and no standards
 - Wireless Truly “no new wires”, but not robust, costly (today), privacy issues, and too many standards



The Phonline Channel

- **Very deep nulls due to stubs with various termination**
 - Phones act like 200-400pf capacitors
 - At the end of 0' to 25' wires, these capacitors create deep in-band nulls
- **Self-NeXT (near-end crosstalk) due to splitterless design and common binder-group**
- **RFI from HAM radio**



Channel Distortion

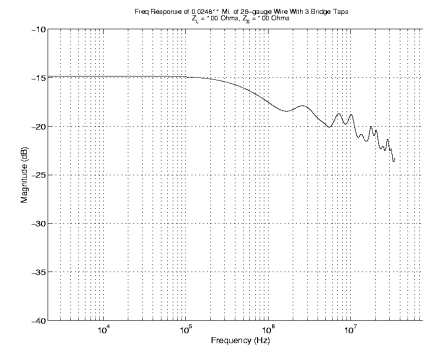
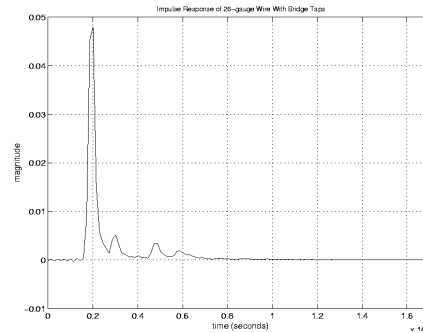
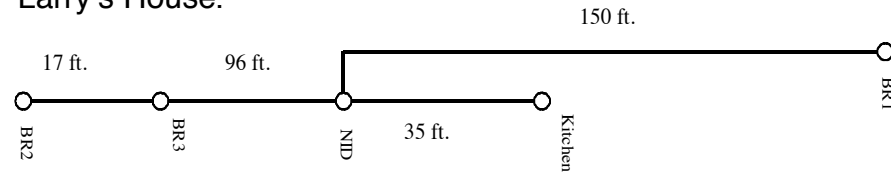
Typical residential wiring may have several stubs.

- Properly terminated stubs cause little distortion.
- Stubs with mismatched termination cause large reflections, spectral notches.

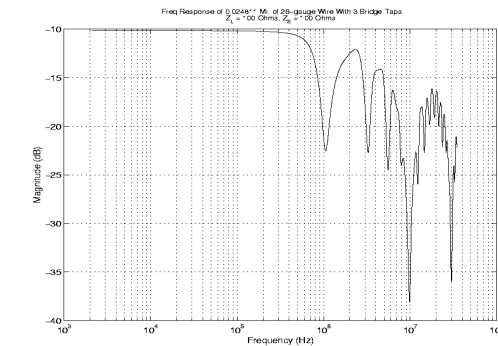
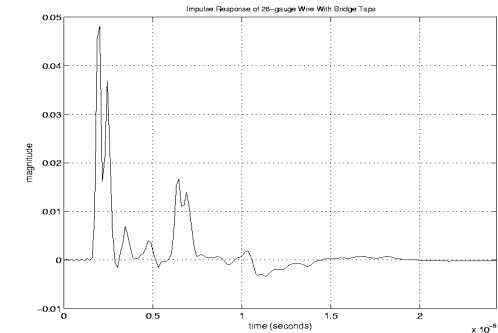
In general, the channel will be different for each pair of devices on the network. The channels may change suddenly

- On/off hook transitions
- keying
- Connecting new devices

Larry's House:



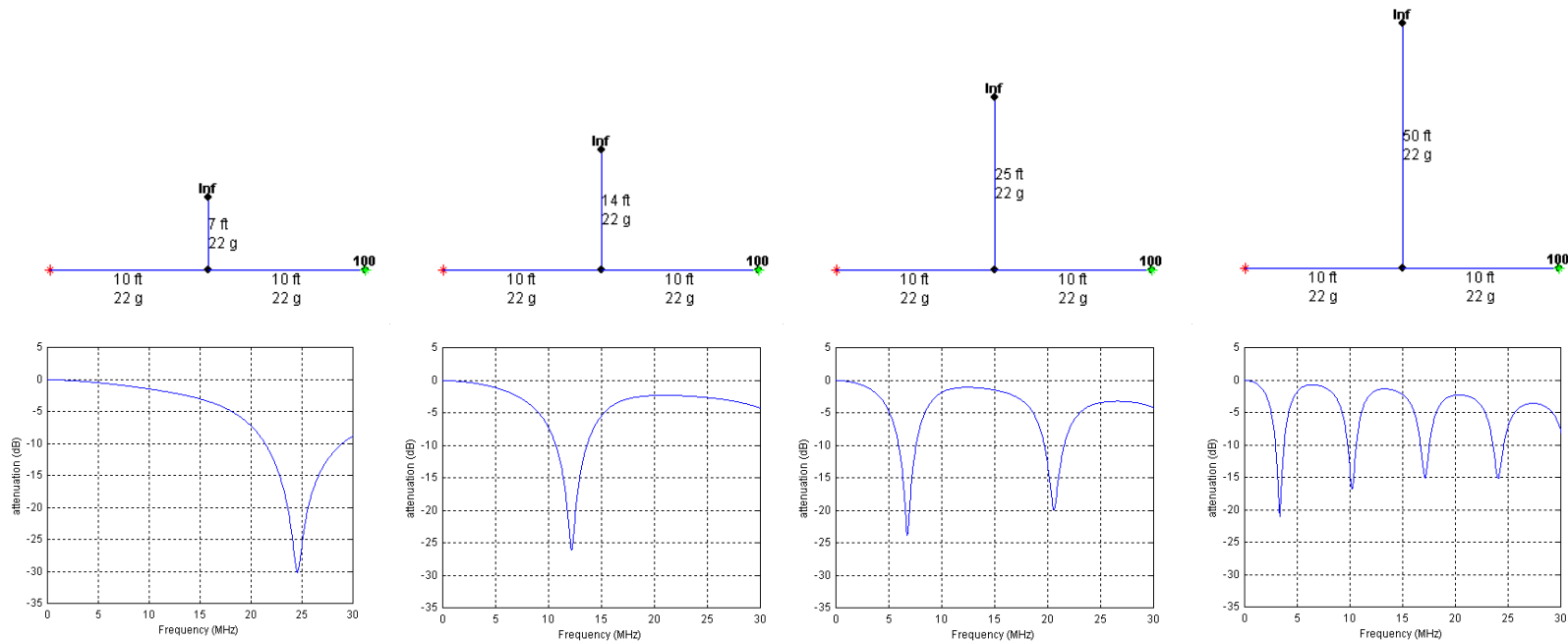
BR3 to Kitchen with terminated stubs.



BR3 to Kitchen with unterminated stubs.



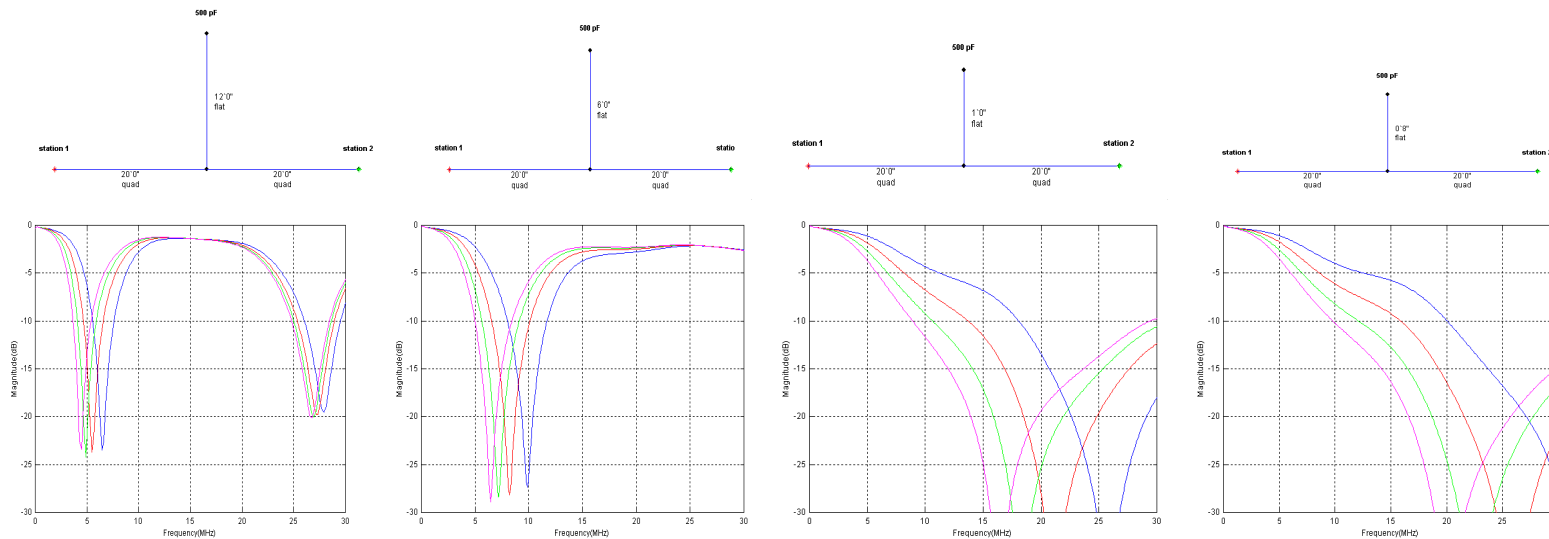
Spectral Nulls Caused by Stubs



- Cascading stubs together can create multiple nulls or deeper nulls.
- Worst case null width is about 1/2 the center frequency of the null
- A null from a single stub can be deeper and wider at high frequencies.

Spectral Nulls from POTS Devices

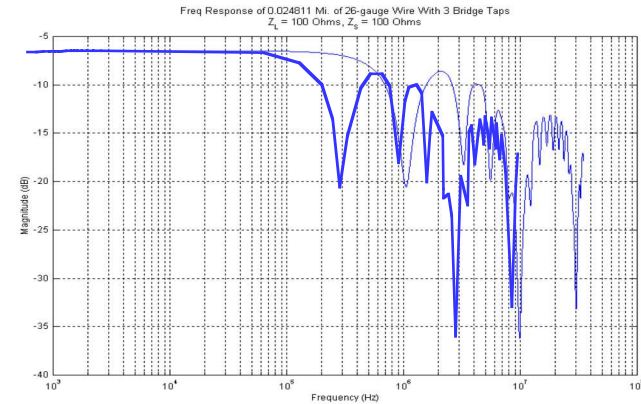
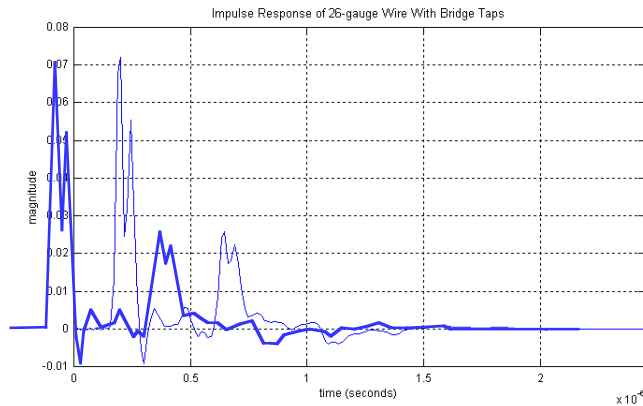
Capacitors: 200 pF, 300 pF, 400 pF, 500pF,



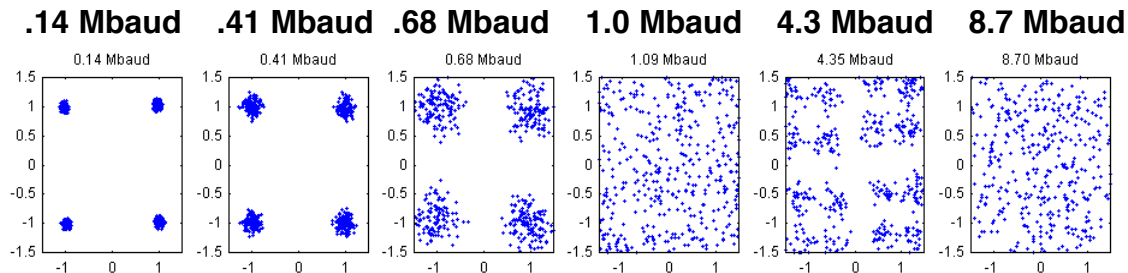
- Many phones can be modeled as capacitors (200-500 pF)
- A phone at the end of a 6-foot stub is very common
- Wall phones are very common (6-12 inch stub)



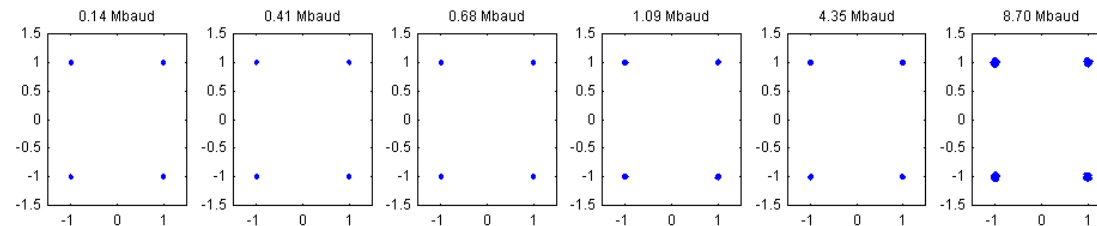
Dynamic Channel Adaptation



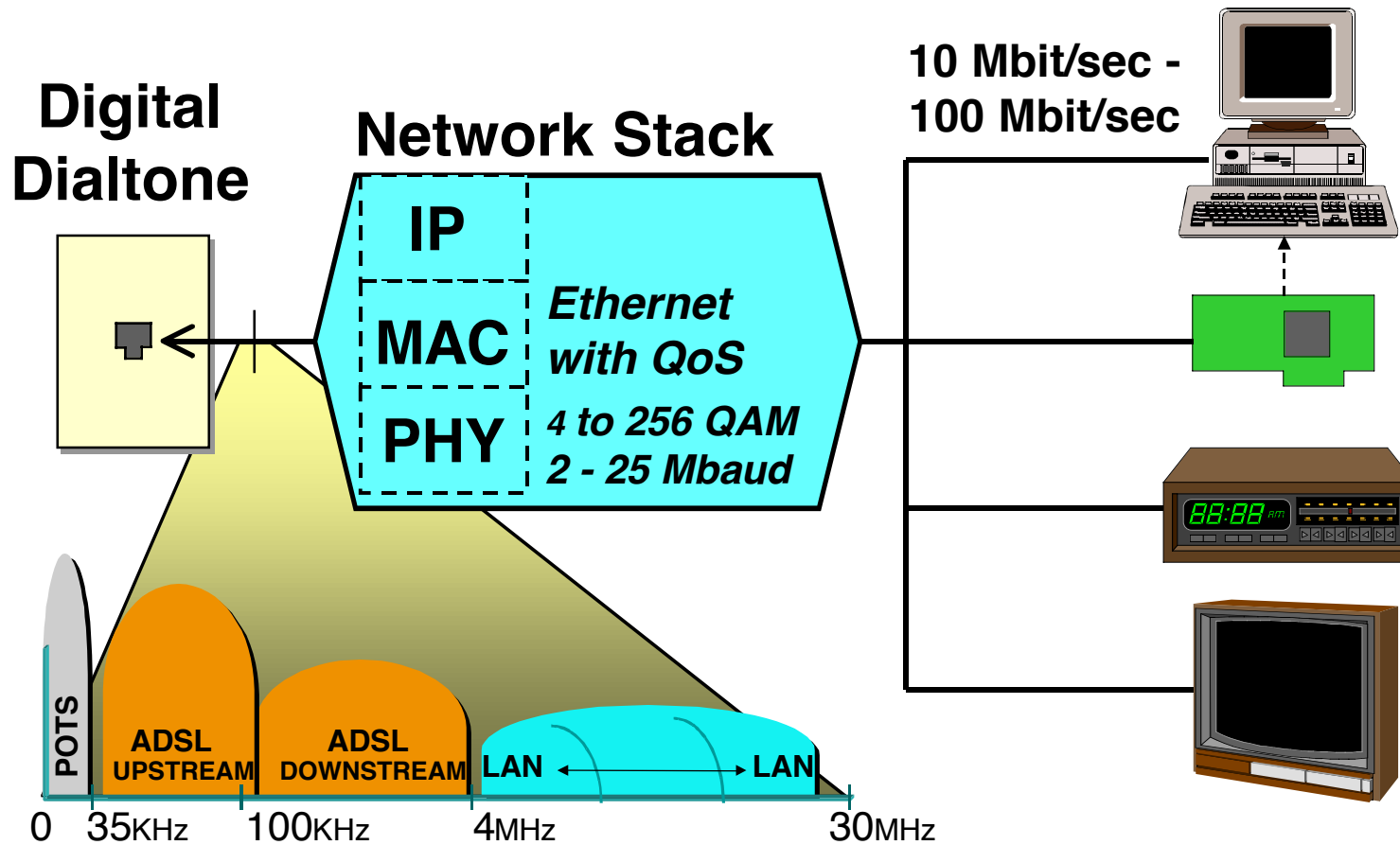
**Raw
Channel**



**With
Broadcom
Dynamic
Channel
Adaptation**



Broadcom iLine10 Phoneline Ethernet



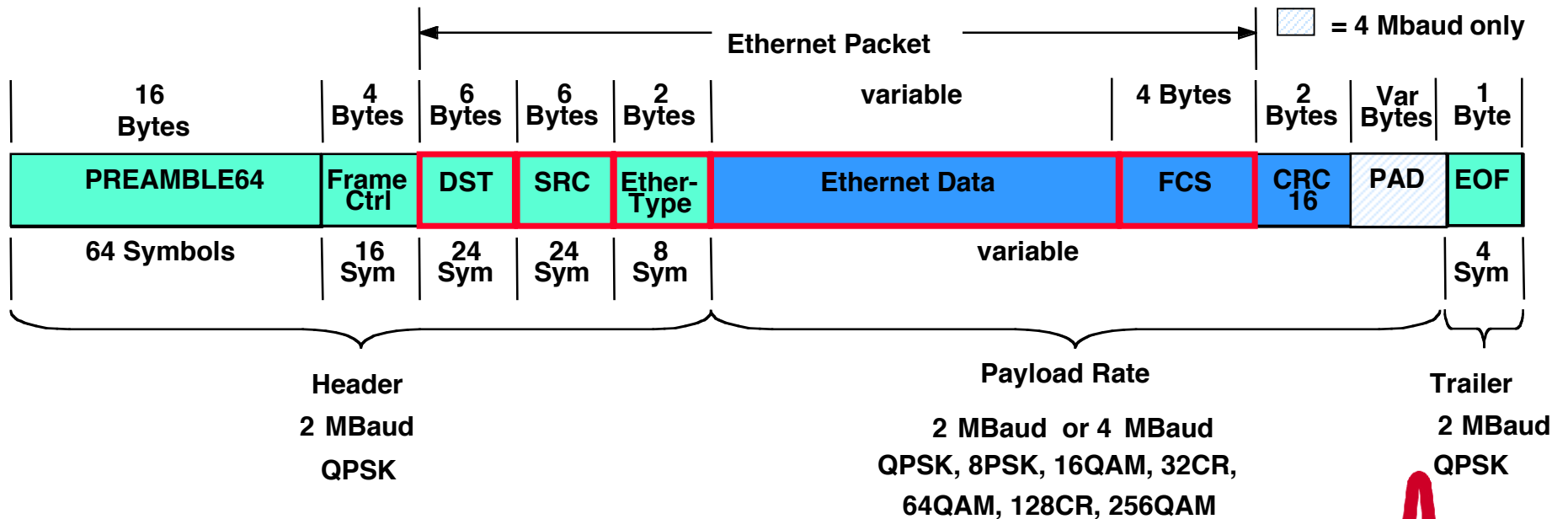
Broadcom iLine10 Phoneline Ethernet

- Works over existing 2-wire, untwisted, unshielded, phone line that is used for POTS
- Compatible with POTS, UADSL
- Dynamically rate and channel adaptive
- Backward compatible with HPNA 1.0 (1 Mbps)
- Forward compatible with Broadcom iLine100
- Integrated QOS support for audio and video
- 802.3 compatible
- On track to be adopted as HPNA 2.0



Packet Format

- Encapsulation of a standard 802.3 frame
- Preamble allows for per packet training and timing recovery



Modulation

- **2 and 4 Mbaud symbol rate**
- **Header uses QAM at 2 bits per symbol (QPSK)**
 - Designed so that all stations can demod header
- **Payload uses QAM at 2 to 8 bits per symbol**
 - Typical channels use 5 to 7 bits per symbol.
 - Lower bits per symbol allow communication even on very impaired channels.
 - Payload bits per symbol is specified per packet, and can change dynamically.
 - 4 to 32 Mbits/sec



Media Access Control (MAC)

- **CSMA/CD, just like 802.3**
- **Enhanced MAC to support controlled traffic**
 - Audio, Video, Telephony are key services within the home
- **Distributed Fair Priority Queuing (DFPQ)**
 - Bounded latency unlike Binary Exponential Backoff (BEB)
 - No central arbitration
 - Driver compatible with 802.1p/q

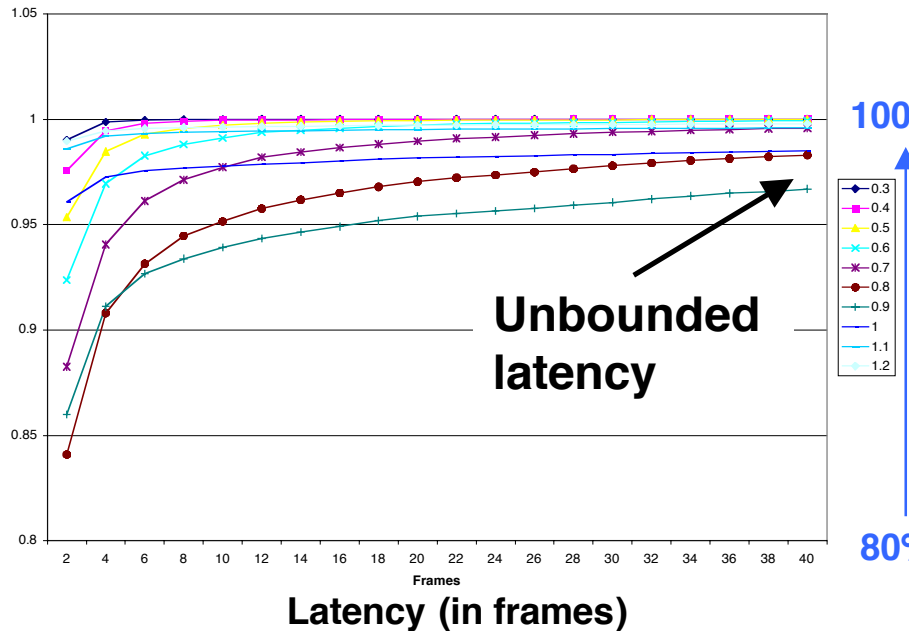


BEB vs DFPQ

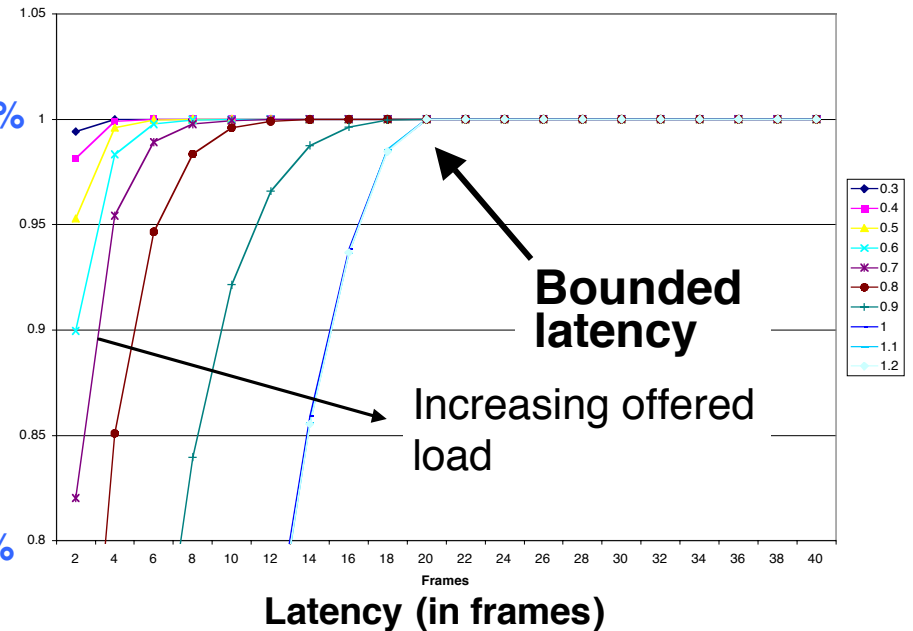
Unbounded latency of BEB MAC makes it unsuitable for audio and video applications

Bounded latency of DFPQ MAC makes it ideal for audio and video applications

Ethernet CSMA/CD



iLine10 CSMA/CD with DFPQ



Cumulative Distribution vs. Access Latency

10 stations, exponential interarrival times, 1500 byte packets, 50,000 packets simulated



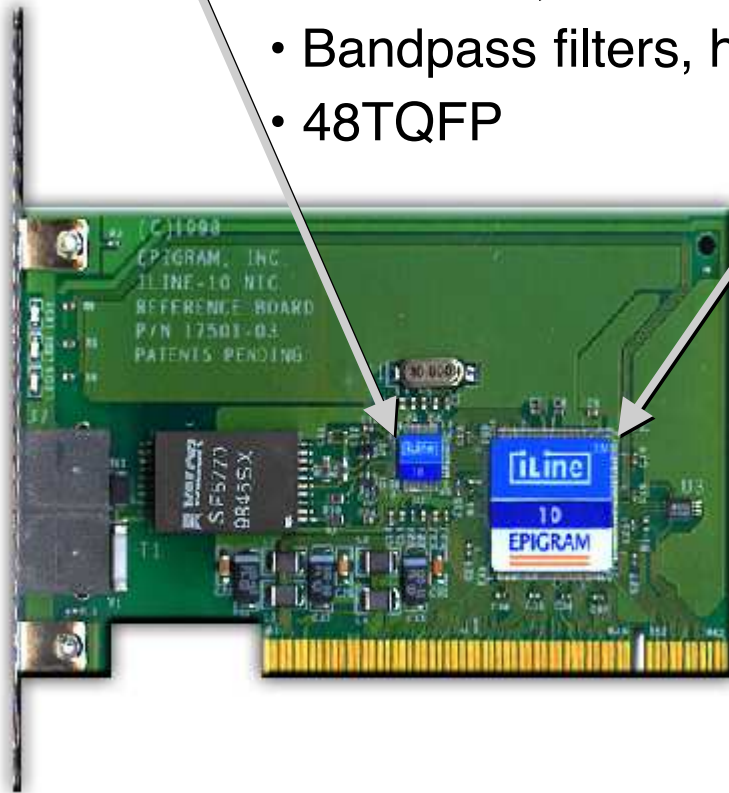
Two-Chip iLine10 NIC

BCM4100 AFE

- 10 bit D/A, A/D
- Bandpass filters, hybrid
- 48TQFP

BCM4210 MAC/PHY

- HPNA 2.0 and HPNA 1.0
- PCI 2.2 bus interface
- Digital PHY processor
- Digital filtering
- CSMA/CD with DFPQ MAC
- 144TQFP



Driver Support

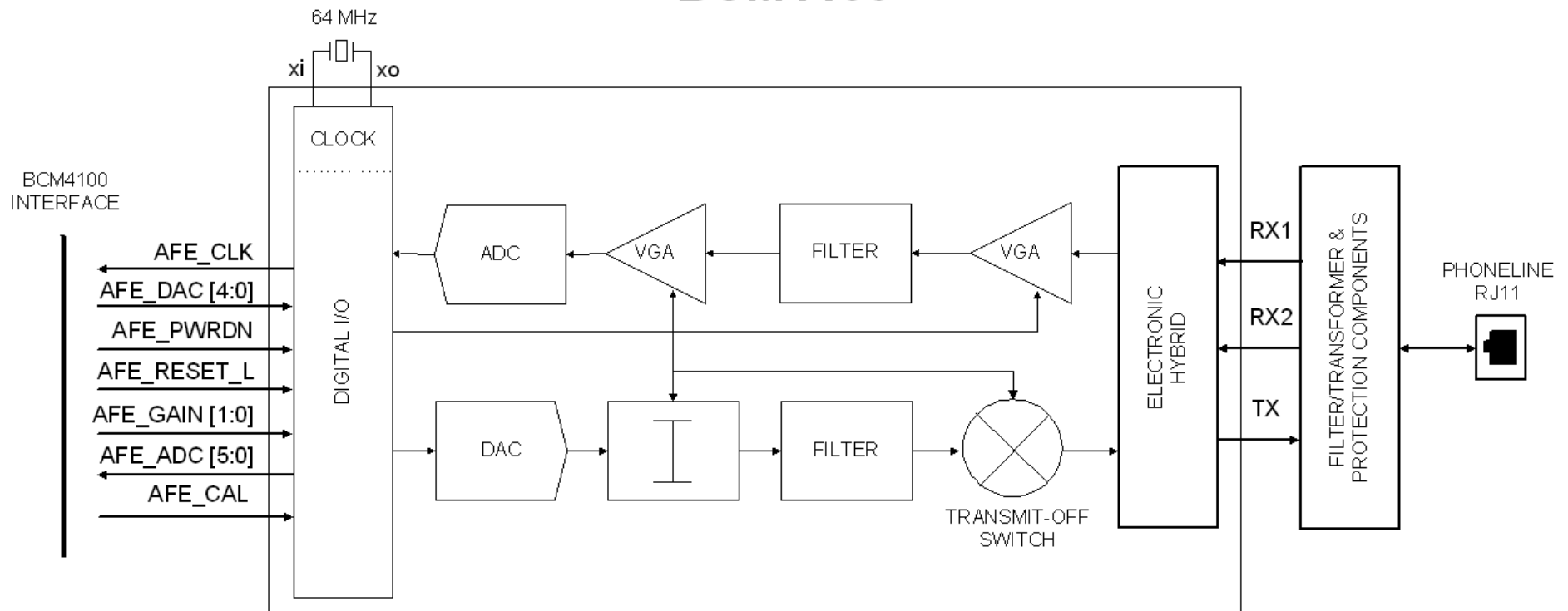
- NDIS 3.1, 4.0, 5.0
- Linux/Unix
- PC98, PC99
- WHQL tested



BCM4100 Analog Front End

- Single-chip analog transceiver

BCM4100

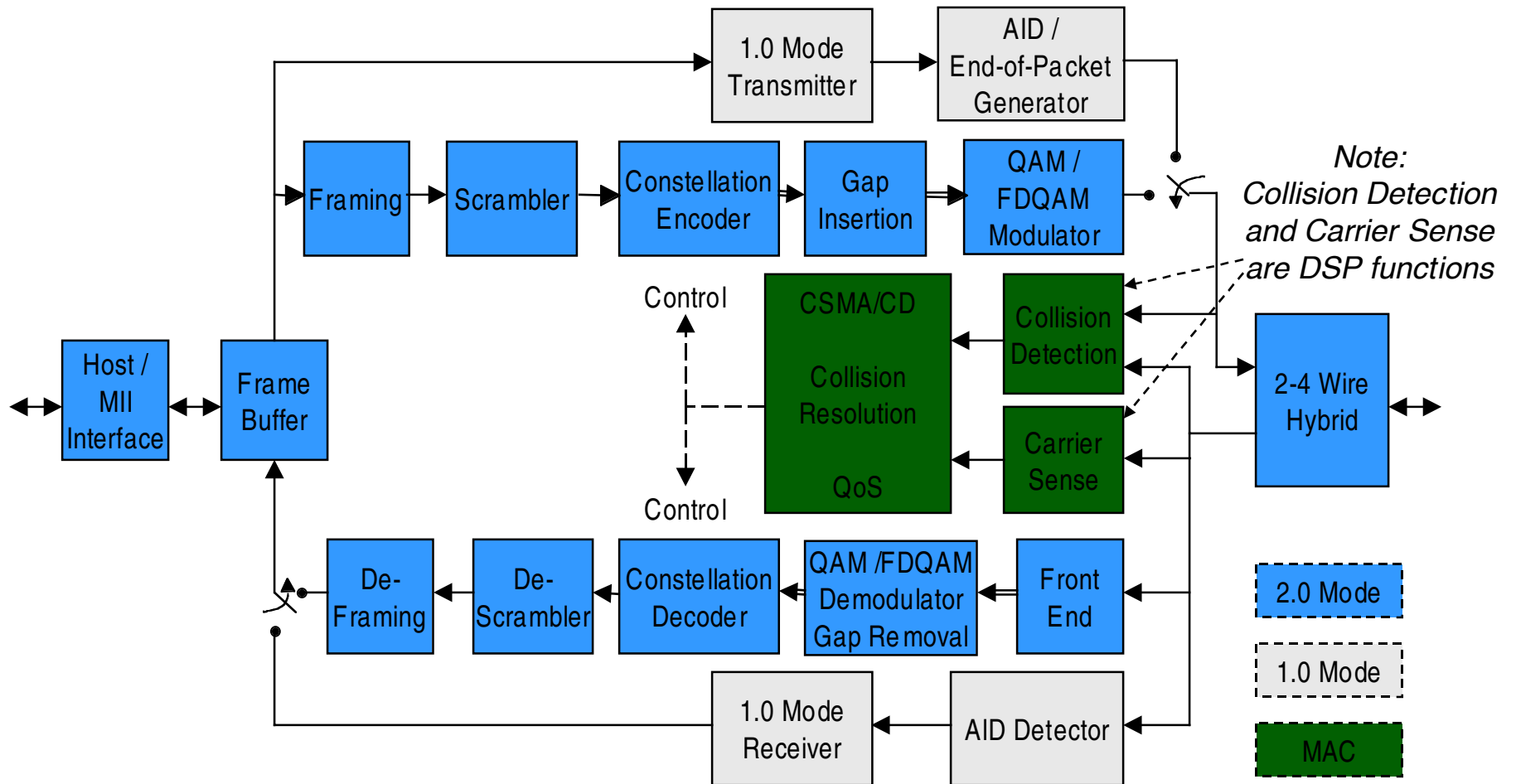


BCM4100 Implementation Details

- **Full custom, .35um double poly, 3.3V, 500mW**
 - Double poly was used to reduce die size
- **3.1mm x 4.1mm, 48 pin TQFP**
- **32 MSPS, 10 bit differential DAC & ADC**
- **Performance**
 - 9.2 effective number of bits (ENOB)
 - Max input voltage: 2.2V p-p differential
 - Min input voltage: 18mV p-p differential (for 2 bits per symbol)



BCM4120 Integrated MAC/PHY



BCM4120 Implementation Details

- **Standard cell, .25um CMOS, 3.3V, 500mW**
- **4.5mm x 4.5mm, 144 pin TQFP**
- **400,000 gates & ~56 Kbits SRAM**
- **64MHz clock**
 - Clocks turn off “automatically” when there is no activity
- **Peak 2700M MACs/sec receive
700M MACs/sec transmit**
 - Most are in the range of 10 x12 bit, many use CSD structures



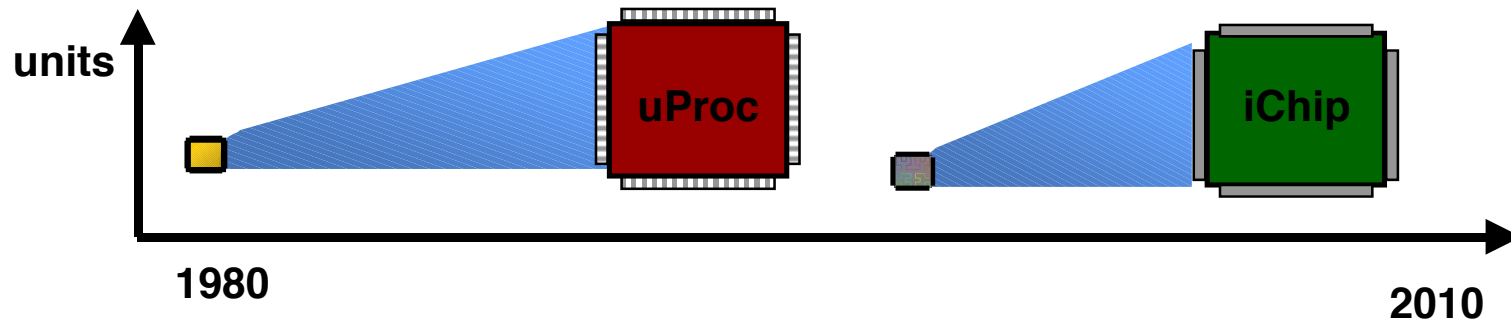
Predictions

- **Home Phonetline Ethernet installed base greater than 10M homes by end of year 2000**
- **Home Phonetline Ethernet will ultimately become the largest installed base of Ethernet**
- **Some Christmas soon after 2000 we will experience a fad over a networked toy, and that morning 20 million new hosts will appear on the Internet**



And The 'Internet Inside'

Over the last 17 years, the microprocessor has become an essential component in all electronic devices



Over the next decade, the “iChip” will become an essential component, alongside the microprocessor

